PATENT SPECIFICATION

DRAWINGS ATTACHED

1,095,056

1,095,056

THE PATENT OFFICE LONDON

Date of Application and filing Complete Specification: July 21, 1966.
No. 32845/66.
Application made in United States of America (No. 482302) on Aug. 24, 1965.
Complete Specification Published: Dec. 13, 1967.

Index at acceptance:—**G1** A(20Y, 203, 218, 24Y, 242, 269, 316, 35Y, 352, 359, 369, 372, 378, 382, 388, 626, 750, 761); **C2** CX5; **G6** R1

Int. Cl.:—**G 01 t 1/00**

COMPLETE SPECIFICATION

A Method of Measuring Combustion Engine Crankcase Oil Consumption

ERRATA

SPECIFICATION No. 1,095,056

Page 3, line 72,

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THE PATENT OFFICE
10th March 1969

ERRATA

SPECIFICATION No. 1,095,056
Slip No. 2

Page 3, line 72,

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THE PATENT OFFICE
12th May 1969

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Int. Cl.: —**G 01 t 1/00**

COMPLETE SPECIFICATION

A Method of Measuring Combustion Engine Crankcase Oil Consumption

We, GENERAL MOTORS CORPORATION, a Company incorporated under the laws of the State of Delaware, in the United States of America, of Grand Boulevard, in the City of Detroit, State of Michigan, in the United States of America (Assignees of DOUGLAS PAUL KRAUSE, WALTER HERMAN LANGE, WILLIAM JOHN MAYER and CALEB PERRY MOORE) do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to a method for measuring crankcase oil consumption and, more particularly, to a method of measuring crankcase oil consumption in a combustion engine by radioisotope tracer techniques.

It has been proposed to use radioactive crankcase oil and to somehow measure the radioactivity of the exhaust gases to determine the oil consumption rate, but such a method has not yielded a practical way of accurately measuring oil consumption since it involves weighing the oil for calibration purposes and is limited by the disadvantages that is difficult to ensure drainage of all the oil for weighing. In addition, the method is limited to measurement of the oil consumption of an entire engine and no method is provided for measuring the oil consumption of an individual cylinder.

These disadvantages are avoided, in the method according to the invention, by using a radioactive tracer in the crankcase oil, operating the engine with a fuel containing a stabilizer or otherwise supplying a stabilizer to the combustion chamber, collecting the tracer element from the exhaust gases and detecting radioactivity of such tracer. More particularly, this invention is carried out by using a crankcase oil containing a radioactive bromine compound, operating the engine with a lead-free fuel having a halide additive such as ethylene bromide, collecting the bromide combustion products from the exhaust gases as by reacting with sodium hydroxide, detecting the radioactivity of the resultant solution and comparing this with the specific activity of the crankcase oil.

The scope of the invention is defined by the appended claims; and the invention and the method by which it is to be performed are hereinafter particularly described with reference to the accompanying drawings, in which: —

Figure 1 is a schematic representation of apparatus used to carry out the method of the invention; and

Figure 2 is a cross-section of a diffuser shown in Figure 1.

It has been found that very accurate measurements of crankcase oil consumption rate can be determined by the method according to this invention, only a few minutes engine running time being required under a given set of operating conditions. To carry out the method there is used an engine oil containing a radioactive halogen tracer which is stable under engine operating conditions and which, after entering a combustion chamber during operation, forms a halide which can be readily collected from the exhaust gases. The radioactivity of a sample of the collected halide compound is detected and compared with the specific activity of the crankcase oil to determine the amount of oil consumed during the period of engine operation. Of the halogens, iodine and bromine are preferred as tracers but bromine is superior due to the stability of its compounds when heated.

[*Price 4s. 6d.*]

SEE ERRATA SLIP ATTACHED

It has been found that this method gives the most accurate results under all engine operating conditions when the engine fuel is lead-free and contains a special additive. The reason the additive is required is not fully understood, but it has been noted that at low engine loads the measured oil consumption was much lower than the actual oil consumption, thus indicating that the tracer somehow failed to be collected from the exhaust gases. It was learned, however, that the addition of a stabilizer or carrier such as an ethylene halide corrected this fault and permitted the collection of the tracer. It is believed that the loss of the tracer is due to small amounts of it reacting with or being absorbed by something in the engine. These small amounts can represent a large percentage of the tracer, as only traces of the radioactive material are present in the combustion chamber and exhaust system. By adding to the system relatively large amounts of a non-radioactive compound the same as or similar to the tracer material, most of the reacted or absorbed material is supplied by the non-radioactive compound and relatively small amounts of the tracer compound are lost. This nonradioactive compound is referred to herein and in the appended claims as a stabilizer. Under some conditions the stabilizer may not be required but it is to be understood that small amounts of it are to be used when needed. A preferred material for use as the stabilizer is ethylene bromide, extremely accurate results having been obtained through its use. Other advantages of ethylene bromide are that it is economical and readily available since it is a conventional additive for use with leaded gasolines, its function there being to react with the lead to avoid lead deposits in the engine. When leaded fuel containing ethylene bromide is used during oil consumption tests, it has been found that excessive amounts of ethylene bromide are required and that these amounts are deleterious to the engine and, in addition, may cause malfunction of the engine which could result in spurious test results. Only very small amounts of ethylene bromide added to lead-free gasoline are required. Tests have been made with 1—7 cc. of ethylene bromide per gallon of gasoline and no difference in performance or test results was noted throughout that range but the results are significantly different when the stabilizer is omitted.

A bromine compound is preferred as the radioactive tracer added to the crankcase oil because: its gamma radiations are readily detectable; it can be formulated into a compound which is very stable under engine operating conditions; and it has a 36-hour half-life, so that it decays sufficiently slowly for it to be used for many hours for a series of tests, but presents no disposal problem because after several days its radioactivity has substantially ceased. Also, bromine can be easily collected from the exhaust gases by reaction with a sodium hydroxide solution for detection of its radioactivity. A preferred tracer is 1,2-dibromo-octadecane synthesized from radioactive bromine, although other compounds such as 9,10-dibromo-stearic acid have been used successfully. These compounds have proved to be very stable when used as a crankcase oil additive.

When crankcase oil enters a combustion chamber during engine operation, the tracer compound forms hydrogen bromide which is carried into the exhaust gases. The exhaust gases are passed through a sodium hydroxide solution for reaction therewith so that the bromide is captured in the solution as sodium bromide. The radioactivity of a sample of the solution is measured. Since the activity of the sample is proportional to the amount of oil consumed by the engine, the oil consumption rate is readily computed.

Figure 1 of the drawings generally illustrates test apparatus used to carry out the method of the invention. An engine 10 drives a dynamometer 12 so that predetermined load conditions may be applied to the engine by adjustment of the dynamometer settings. Fuel is supplied to the engine from tank 14. An exhaust pipe 16 carries the exhaust gases from the engine 10 to a diverter valve 18 which can be positioned to exhaust the gases to atmosphere by way of a tube 20 or, alternately, to divert the gases to an extraction tower 22 by means of a tube 24. The tower 22 is about 9 feet tall and 12 inches in diameter. The extraction tower contains several inches of a sodium hydroxide solution 26 in the bottom thereof. A diffuser 28 connected to the tube 24 is immersed in the solution 26 and is adapted to diffuse the exhaust gases through the sodium hydroxide so as to obtain maximum contacts of the gases with the solution and react the hydrogen bromide in the gas with sodium hydroxide. A condenser 30 in the top of the extraction tower prevents excessive loss of water from the tower. The gases are emitted from the top of the tower 22 and vented to atmosphere through a pipe 32. The sodium hydroxide can be delivered to the tower by way of a pipe 34 and can be drained therefrom by way of a drain 36 at the bottom of the tower.

As shown in Figure 2, the diffuser 28 comprises a cylindrical block having a central bore 38 connected to the exhaust tube 24, and an array of small passages 40 which radiate from the central bore 38 so as to diffuse the exhaust gases into the solution 26. The diffuser is designed to produce an exhaust gas pressure drop as small as possible and, accordingly, the combined cross-sectional area of the radiating passages 40 approximates the area of exhaust tube 24. Thus where the exhaust

tube has an internal diameter of 2 inches, the diffuser comprises 250 radial passages each having a diameter of $\frac{1}{8}$ inch.

After the exhaust gas has been passed through the sodium hydroxide solution for a predetermined period, a sample 42 (Figure 1) of the solution is taken from the tower by way of the drain 36 and is collected in a sample holder 44. As indicated by the dotted line, the sample holder 44 is transferred to a well-type scintillation detector 46 where the radiations are detected and counted by a scaler 48.

A specific example of the preferred manner of carrying out the method is as follows: The apparatus is calibrated by determining the collector efficiency. This is done by operating the engine using non-radioactive crankcase oil and bromine-free gasoline and injecting a known amount of nonradioactive hydrogen bromide into the exhaust system and passing the exhaust gases through the sodium hydroxide in the extraction tower. By analyzing the resultant sodium hydroxide-sodium bromide solution as by X-ray fluorescence to determine the amount of the bromide collected, the efficiency of the tower can be calculated. This step is repeated for various engine operating conditions. It has been found that the tower efficiency remains almost constant for all engine operating conditions. In preparing of the tracer additive, 1/2 cc. of bromine having an activity of 40 to 80 millicuries is reacted with 1-octadecene to produce 10 cc. of 1,2-dibromo-octadecane. This active compound is diluted with 15 cc. of carbon tetrachloride and is mixed with 4 quarts of oil in the crankcase. The engine fuel is isooctane gasoline or any non-leaded fuel containing about 4 ml. of ethylene bromide per gallon. The engine is run for about one hour to insure a homogeneous mixture of crankcase oil. A sample of 0.01 cc. of oil is taken from the crankcase and the radioactivity thereof is measured. This sample is used thereafter as an oil standard so long as the same oil is in the engine. The system is now prepared for the first oil consumption test. Twenty litres of a one-molar solution of sodium hydroxide solution are placed in the extraction tower so that the level of the solution in the tower is about 6 inches above the diffuser. The engine thus far has been operating with the diverter valve 18 positioned so as to vent the exhaust gases to atmosphere. The engine and dynamometer are set to any desired speed and load condition and the diverter valve is moved to pass the exhaust gases through the extraction tower for three minutes and then the diverter valve is moved back to its initial position. A 20 ml. sample of the sodium hydroxide-sodium bromide solution is drained from the tower into the sample holder 44 and the radiation of the sample is measured for one minute in a well-type sodium iodide crystal scintillation detector. This concludes the test for one engine operating condition. The oil consumption rate in terms of miles per quart is then computed in a straightforward manner according to the following formulae:

$$\frac{\text{miles}}{\text{quart}}=\frac{\text{miles/hour}}{\text{quarts/hour}}=\frac{\text{miles/hour}}{\frac{a}{e}\times\frac{V}{v}\times\frac{1}{t}\times\frac{1}{A}\times K}$$

where

a=activity of the sample (counts/minute)
e=efficiency of the extraction tower
V=volume of sodium hydroxide solution (ml)
v=volume of the sample (ml)
t=time of the test (minutes)
A=specific gravity of the oil $\frac{\text{(counts/minute)}}{\text{ml.}}$
K=conversion constant $\left(6.35\times10^{-2}\ \frac{\text{quarts/hour}}{\text{ml/minute}}\right)$

Thus in a typical test where the sample activity is 2.5×10^4 counts per minute, the tower efficiency is 65%, the volume of the NaOH is 2×10^4 ml., the volume of the sample is 20 ml., the time of the test is three minutes, the specific activity of the oil is 2×10 counts per minute, and the engine is running at a speed representing 50 miles per hour. The oil consumption rate is 1200 $\frac{\text{miles}}{\text{quart}}$.

A successive test for another operating condition may be performed immediately, it being necessary only to replace the sodium hydroxide solution with fresh solution and repeat the above procedure. If desired, the sodium hydroxide used in the first test may be reused for subsequent tests but the amount of radioactivity caused by the previous tests must be taken into account for each computation of the oil consumption rate. In performing subsequent tests it is unnecessary to predetermine the efficiency of the extraction tower. For subsequent tests the change of activity of the engine oil due to decay is taken into account by reference to the oil standard.

It has been found that the sensitivity of this method is such that approximately 10^{-7} quart (roughly 1/100 of an oil drop) in the exhaust gases can be detected and measured.

To run a complete set of oil consumption curves representing oil consumption plotted against engine load for various engine speeds requires about 36 individual measurements. This can be accomplished by the method of this invention in approximately four hours whereas heretofore a period of 360 hours was required to obtain similar data by the oil

weigh method. The data obtained by the method of this invention are in general agreement with data obtained by the oil weigh method but are believed to be much more accurate owing to the superior sensitivity of the present method coupled with the fact that the tests are completed in a short time the oil weigh method required such long periods of operation that the continuous wearing of the engine actually caused changes in its oil consumption characteristics before the test was completed.

The oil consumption characteristics of a single cylinder of an engine can be measured by using a specialized exhaust manifold which will lead the exhaust from only one cylinder to the extraction tower; and as the tests are performed in a short time, it is practical to evaluate the oil consumption characteristics of a new engine during its break-in period.

WHAT WE CLAIM IS:—

1. A method of measuring crankcase oil consumption of a combustion engine comprising adding a radioactive tracer to the crankcase oil, operating the engine with lead-free fuel, collecting the tracer from the engine exhaust gases for a known time period and detecting the activity of the collected tracer, the detected activity being proportional to the oil consumption.

2. A method according to claim 1, in which said tracer is a radioactive halogen tracer.

3. A method according to claim 1 or 2, in which a tracer stabiliser is supplied to the engine combustion chamber.

4. A method according to claim 3, in which the engine is supplied with lead-free fuel containing said tracer stabiliser.

5. A method according to any of claims 1 to 4, in which said tracer is a radioactive bromine tracer.

6. A method according to claim 3, 4 or 5, in which said stabiliser is a bromide.

7. A method according to any of claims 1 to 6, in which the activity of the sample is compared with the specific activity of the crankcase oil to determine the oil consumption of the engine.

8. A method according to any of claims 1 to 7, in which the exhaust gases are collected from only one cylinder of the engine, in order to determine the oil consumption of said one cylinder only.

9. A method according to any of claims 1 to 8, in which said engine is operated with crankcase oil containing 9,10-dibromo-stearic acid having a radioactive bromine tracer, and fuel containing ethylene bromide is fed to the engine.

10. A method according to any of claims 1 to 8, in which the engine has crankcase oil containing 1,2-dibromo-octadecane having a radioactive bromine tracer, and a lead-free fuel containing ethylene bromide is fed to the engine.

11. A method according to any of claims 1 to 10, in which the exhaust gases are reacted with a sodium hydroxide solution to collect therefrom radioactive halide, the activity of which is compared with the specific activity of the crankcase oil.

12. A method of determining the crankcase oil consumption of a combustion engine, substantially as hereinbefore particularly described with reference to the accompanying drawings.

E. WILLIAMSON,
Chartered Patent Agent.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

1095056 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

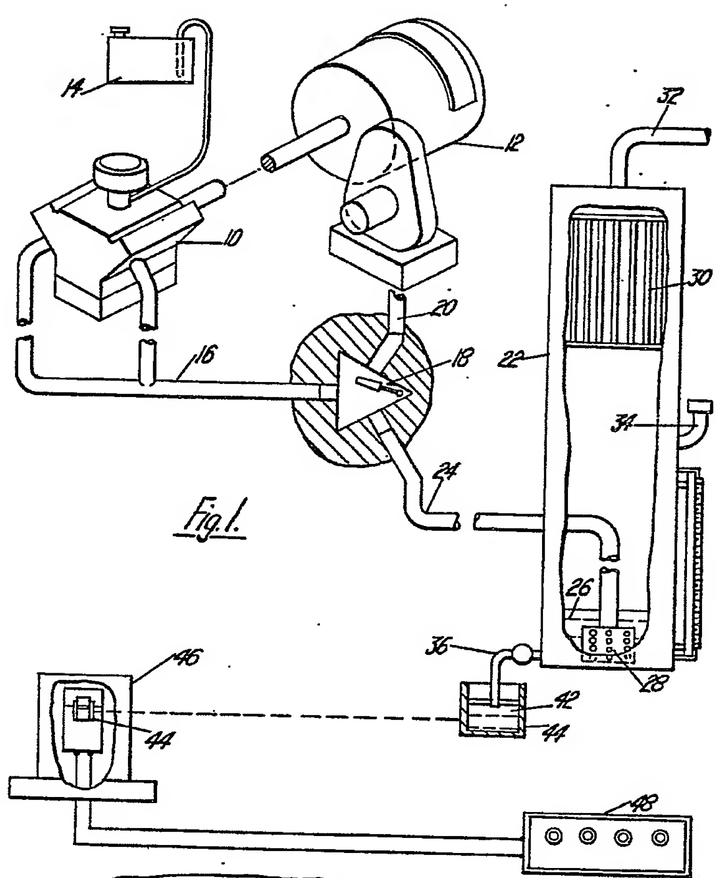

Fig. 1.

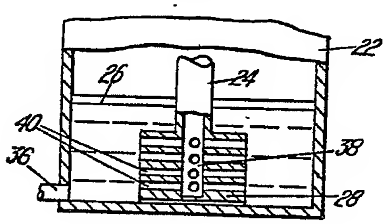

Fig. 2.